Phase State and Physical Properties of Ambient and Lab Generated Aerosols: X-ray Microscopy

Research Highlight

Models of secondary organic aerosol (SOA) formation assume that the organic fraction is a liquid with condensed phase-diffusion rates fast enough to maintain equilibrium with the gas phase. However, numerous recent studies looking at particle bounce behavior, evaporation, thermal desorption, diffusion, physical manipulation, etc., have all shown that organic matter in aerosols can have higher viscosities. Most of these studies have been carried out on laboratory generated aerosols and only a few have compared laboratory and ambient samples. Thus, the phase state of ambient SOA, whether solid/glassy or liquid, is not well understood.

This study uses Scanning Transmission X-ray Microscopy (STXM) at the carbon K-edge to image impacted organic aerosol particles and measure their size (area equivalent diameter) and their average thickness on the substrate. STXM is an x-ray absorption technique that, at the carbon K-edge, provides information on the thickness of the carbon and of any inorganic in the particles. When particles are collected in an impactor, lower viscosity particles will flatten more upon impaction and will be thinner (for a given size) than higher viscosity particles. Thus, particles with a higher viscosity will have a steeper slope on a plot of size as a function of thickness.

Data sets for identified organic aerosols from five different field campaigns were analyzed and compared to the amount of deformation of SOA generated in a chamber and a flow tube using isoprene, alpha-pinene, and limonene precursors under various oxidizing conditions. All of the ambient campaigns had similar slopes. Each was within the 95 percent confidence interval of at least two of the other samples. All of the laboratory generated samples had smaller slopes than the ambient samples and all but one were within the 95% confidence intervals of the others. The outlier was isoprene SOA generated under high NO_x conditions which showed a slope close to zero indicating that the organic was very liquid-like. Additionally, the ambient particles, while still organic dominated, were found to have a higher inorganic content than the laboratory generated particles.

The results of this study have implications for both future SOA models and comparisons of results from laboratory SOA studies to field measurements. First, the similarity between the impaction behaviors of all of the ambient samples indicates that a small range of viscosities may be appropriate to describe the average aerosol population in SOA models. This is in spite of the fact that the different field sites spanned the northern and southern hemispheres and had different sources, meteorology, and aging processes. Second, the observed lower viscosity of the laboratory-generated particles indicates that care should be taken when comparing results of analysis of laboratory-generated particles to ambient analysis and when applying data from laboratory studies to SOA models.

Figure 1. Map showing the geographic locations of the five field campaigns. Samples from the VOCALS campaign in Chile and the NAOPEX campaign in the Boston area were aerial samples, MILAGRO, CARES, and YACS samples were collected at the ground sites.
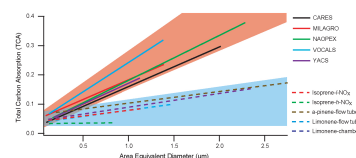

Figure 2. Total carbon absorption as a function of size of the impacted organic particles. Solid and dashed lines: linear fit lines for the ambient and laboratory generated particles, respectively. The red and blue areas highlight the range of the ±95% confidence intervals for the ambient and laboratory samples respectively.

Reference(s)

O'Brien RE, A Neu, SA Epstein, AC MacMillan, B Wang, ST Kelly, SA Nizkorodov, A Laskin, RC Moffet, and MK Gilles. 2014. "Physical properties of ambient and laboratory-generated secondary organic aerosol." Geophysical Research Letters, 41(12), doi:10.1002/2014GL060219.

Contributors

Rachel E. OBrien, *Lawrence Berkeley National Laboratory*; Mary Gilles, *Lawrence Berkeley National Laboratory*

Working Group(s)
Aerosol Life Cycle

U.S. DEPARTMENT OF ENERGY | Office of Science